



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Lin et al.

Art Unit: 2613

Application No. 09/201,278

Filed: November 30, 1998

For: EFFICIENT MOTION VECTOR CODING  
FOR VIDEO COMPRESSION

Examiner: Vu Le

Date: December 5, 2002

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- ☒ Appeal Brief and Appendices A-C (in triplicate)
- ☒ A check in the amount of \$320.00 to cover the above-listed fee for filing appeal brief
- ☒ Applicants petition for an extension of time for 1 month. If an additional extension of time is required please consider this a petition therefor.
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Kyle B. Rinehart  
Attorney for Applicant

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**APPEAL BRIEF**

This brief is in furtherance of the Notice of Appeal filed August 26, 2002 and received by the U.S. Patent and Trademark Office September 5, 2002. The fee required under 37 CFR 1.17(c) is enclosed.

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**I. REAL PARTY IN INTEREST**

The real party in interest is Microsoft Corporation, by an assignment from the inventors recorded at Reel 9650, Frames 0683-0685. Microsoft Corporation is a Washington corporation having a place of business at 1 Microsoft Way, Redmond, Washington, 98052.

**II. RELATED APPEALS AND INTERFERENCES**

No other appeals or interferences relate to the present application.

**III. STATUS OF CLAIMS**

Claims 1-22 are in the application, of which claims 1, 3-13 and 15-22 are pending. No claims are allowed. Claims 2 and 14 were previously cancelled.

The claims on appeal are 1, 3-13 and 15-22. A clean copy of the claims on appeal is presented in Appendix A.

**IV. STATUS OF AMENDMENTS**

All amendments have been entered.

**V. SUMMARY OF THE INVENTION**

Applicants' invention relates to coding and decoding motion vectors for video coding and decoding applications.

One aspect of the invention involves jointly coding the x and y components of a motion vector with a single entropy code. To exploit statistical dependence between the x and y motion vector components, an encoder assigns a single variable length code ("VLC") from a VLC table (sometimes referred to as a "codebook") to jointly represent the x and y components. [See, e.g.,

Application at page 4, line 26 - page 5, line 5.] Including VLCs in the VLC table for all possible pairs of x and y components can make the VLC table inefficiently large. So, the encoder uses training (e.g., by statistical analysis of example video sequences) to determine which pairs of x and y components are to be represented by VLCs from the VLC table, and which pairs are to be represented using an escape code plus non-VLC (e.g., literal) values.

For example, the encoder uses the training to put the most likely pairs of x and y components in the VLC table. To represent a pair of x and y components, a VLC uses less bits than the escape code plus non-VLC values. Thus, the encoder reduces the average bitrate associated with motion vectors by using VLCs for the most likely pairs of x and y components and using the escape code plus non-VLC values for the other pairs. To further reduce the average bitrate, for the pairs represented in the VLC table, the encoder assigns shorter VLCs to more likely pairs and longer VLCs to less likely pairs. [See, e.g., Application at page 10, lines 12-24.]

In another aspect, an encoder uses joint coding of motion vector components in combination with motion vector prediction. For example, an encoder first computes a predictor for a motion vector, and then computes differential motion vector ("DMV") x and y components between the x and y components of the motion vector and its predictor. The encoder then computes a single VLC for a joint parameter representing both the x and y differential components. [See, e.g., Application at page 10, line 25 - page 12, line 11; Fig. 3.] The encoder uses training to determine which pairs of differential x and y components are to be represented by VLCs from a VLC table, and which pairs are to be represented using an escape code plus non-VLC values.

Applicants attach a chart (Appendix B) showing a plot of pairs of differential x and y components ("DMV pairs") represented in the VLC table labeled Table 1 at pages 14-27 of the Application. The plot of DMV pairs does not follow a set geometric pattern. Rather, the plot reflects that the charted VLC table *includes DMV pairs determined by training to be more likely than*

*the non-included pairs for typical content of a particular type* (namely, talking head video). For example, the charted VLC table includes disproportionately more DMV pairs in predominantly horizontal directions and predominantly vertical directions than in other directions. This typically results in more efficient compression for video in which horizontal or vertical motion (e.g., due to panning) is more common than diagonal motion. As another example, the charted VLC table includes several examples of DMV pairs of a large magnitude in a particular direction (e.g., (-16, 0), (-15, 0)) even though DMV pairs of lesser magnitude in the same direction (e.g., (-10.5, 0), (-11, 0)) are not included in the table. This may result in more efficient compression for video in which quick camera movement (e.g., quick panning to another person) is more common than a medium movement in the same direction.

A decoder performs the inverse of the encoder operations to reconstruct motion vectors from variable length codes. When an encoder uses motion vector prediction, a decoder also uses motion vector prediction to work with the same predictors.

The invention can be used in a variety of video coding and decoding applications, including both object-based and frame-based coding and decoding.

## VI. ISSUES

Whether the Office met its burden of establishing that claims 1, 3-4, 7-9, 11-13, and 15-22 are anticipated by Yu et al., "Two-Dimensional Motion Vector Coding for Low Bitrate Videophone Applications," *Proc. Int'l Conf. on Image Processing*, p. 414-17 (1995) ("Yu").

Whether the Office met its burden of establishing obviousness of claims 5-6 and 10 in view of Yu.

## **VII. GROUPING OF CLAIMS**

For reasons detailed below, independent claims 1, 7, 11, 13, 16, 19, 20, and 22 are each independently patentable. The dependent claims each contain limitations that further distinguish over the art of record. However, since the limitations of the independent claims are sufficient to distinguish this art, and to facilitate the Board's consideration of this appeal, Applicants group the claims for purposes of this appeal as follows.

The patentability of claims 3-6 stands or falls with the patentability of claim 1.

The patentability of claims 8-10 stands or falls with the patentability of claim 7.

The patentability of claim 12 stands or falls with the patentability of claim 11.

The patentability of claim 15 stands or falls with the patentability of claim 13.

The patentability of claims 17 and 18 stands or falls with the patentability of claim 16.

The patentability of claim 21 stands or falls with the patentability of claim 20.

## **VIII. ARGUMENT**

### **A. Yu**

Yu describes jointly coding horizontal ("x") and vertical ("y") DMV components. [See Yu at page 414.] Yu places all possible DMV pair values in a square reaching from -31.5 pixels to 31.5 pixels on both the x and y axis. The square is divided into three regions: Region A is the square reaching from -8 to 8 on both the x and y axis; Regions B and C cover the remainder of the area. [See Yu at page 415.]

Yu describes a 290-code VLC table for pairs of DMV components in Region A, since "[m]ost DMVs fall into [Region A] because the frequency of occurrence for small DMVs is very high." [See Yu at page 415.] The 290 codes represent each possible pair in Region A in which each component has an absolute value of from 0 to 8 in half-pixel steps (17 half-pixel steps x 17 half-



pixel steps + 1 escape code). Sign bits are used for non-zero values. [See Yu at page 415.] The escape code is used to encode pairs in Region B. [See Yu at pages 415-16.] Pairs in Region C share the same codes with pairs in Region A or B, but incorporate an offset of  $\pm 32.0$  pixels to distinguish the Region C code from the Region A or B code. [See Yu at page 416.] For the pre-determined pairs to be represented in the VLC table (i.e., the pairs of Region A), Yu then determines the relative lengths of VLCs for the DMV pairs. To do this, Yu creates a histogram of frequencies of occurrence for DMV pairs in a “training set” of five test video sequences. After “smoothing” the histogram, Yu generates the VLCs for the DMV pairs in Region A.

To facilitate direct comparison with the chart of Appendix B, Applicants attach a chart (Appendix C) showing a plot of DMV pairs (i.e., pairs in Region A) represented in the Yu VLC table. The Yu VLC table includes DMV pairs in a square region around the center (0, 0).

*The Yu VLC table assumes, before training, that each and every pair of DMV  $x$  and  $y$  components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu states that “the VLC code table is obtained based on a finite number ... of video sequences” [see Yu at page 417], the number and identity of the DMV pairs to be represented by codes in the VLC table are not determined by training or statistical analysis. Rather, only the lengths of the codes are determined by training.*

In other words, Yu describes, for a pre-determined set (Region A) of DMV pairs, calculating VLCs based upon frequencies of occurrence in a training set of test sequences. Yu uses the training set to determine the relative lengths of the VLCs for the DMV pairs in the VLC table, not to select the DMV pairs for the VLC table.

**B. The Rejections of Claims 1, 3-4, 7-9, 11-13, and 15-22 Under 35 U.S.C. § 102(b) as Being Anticipated by Yu Should Be Reversed.**

Claims 1, 3-4, 7-9, 11-13, and 15-22 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Yu. Yu fails to teach or suggest at least one element of each one of these claims. Accordingly, the rejections of claims 1, 3-4, 7-9, 11-13, and 15-22 should be reversed.

**1. Claim 1**

Claim 1 is directed to improving compression of video images in a video coder.  $x$  and  $y$  motion vector components for a current block of pixels are predicted based on a motion vector of at least one neighboring block of pixels to compute  $x$  and  $y$  components of a predictor motion vector. Differential  $x$  and  $y$  components are computed from the components of the predictor and the components of a motion vector for the current block. A single VLC from a VLC table is assigned to joint  $x$  and  $y$  DMV components. The VLC table comprises a list of pairs of joint DMV components and a corresponding VLC for each pair. The VLC table includes the most probable pairs of joint DMV components as computed by statistical analysis of example video sequences.

Specifically, claim 1 recites:

wherein the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences.

Applicants submit that the Examiner has not met the burden of establishing that claim 1 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 1.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV  $x$  and  $y$  components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set

of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences,” as recited in claim 1.

Accordingly, the rejections of claims 1 and 3-6 should be reversed.

## 2. Claim 7

Claim 7 is directed to decoding macroblocks of a predicted video frame in a video decoder. A single variable length code representing joint x and y components of a motion vector for each of the macroblocks is received. For each of the macroblocks, a single entry in an entropy codebook is searched for. The entry corresponds to the variable length code and includes the x and y components of the motion vector. Training determines which x and y components to include in the entropy codebook.

Specifically, claim 7 recites:

wherein training determines which x and y components to include in the entropy codebook

Applicants submit that the Examiner has not met the burden of establishing that claim 7 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 7.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be

represented in the VLC table. Thus, Yu does not teach or suggest, “wherein training determines which x and y components to include in the entropy codebook,” as recited in claim 7.

Accordingly, the rejections of claims 7 and 8-10 should be reversed.

### 3. Claim 11

Claim 11 is directed to a motion vector encoder comprising a motion vector predictor for computing a motion vector predictor, a subtractor for computing DMV components, and a joint entropy coder for jointly coding the DMV components with a single VLC. Statistical analysis indicates which DMV components to represent with VLCs and which DMV components to represent with an escape code followed by fixed-length codes.

Specifically, claim 11 recites:

wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes.

Applicants submit that the Examiner has not met the burden of establishing that claim 11 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 11.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes,” as recited in claim 11.

Accordingly, the rejections of claims 11 and 12 should be reversed.

#### 4. Claim 13

Claim 13 is directed to a motion vector decoder comprising a motion vector predictor for computing a motion vector predictor, a joint entropy decoder for decoding a single VLC into joint DMV components, and an adder for reconstructing X and Y motion vector components. The joint entropy decoder decodes the single VLC by searching for the code in a Huffman coding table comprising a list of VLCs and corresponding joint DMV components for each of the VLCs. Training determines which joint DMV components to include in or exclude from the table.

Specifically, claim 13 recites:

wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table.

Applicants submit that the Examiner has not met the burden of establishing that claim 13 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 13.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table,” as recited in claim 13.

Accordingly, the rejections of claims 13 and 15 should be reversed.

## 5. Claim 16

Claim 16 is directed to a method for improving compression of video images in a video coder. The method comprises computing x and y motion vector components for a block and forming the x and y motion vector components into a joint parameter representing joint x and y motion vector components. A single VLC is assigned to the joint x and y motion vector components. The single VLC is selected from a set of available VLCs. Training determines which joint x and y motion vector components to represent in the set of available VLCs.

Specifically, claim 16 recites:

wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

Applicants submit that the Examiner has not met the burden of establishing that claim 16 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 16.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes,” as recited in claim 16.

Accordingly, the rejections of claims 16 and 17-18 should be reversed.

**6. Claim 19**

Claim 19 is directed to a method for decoding macroblocks of a predicted video frame in a video decoder. The method comprises receiving a single VLC representing joint differential x and y components of a motion vector for each of plural macroblocks. For each of the macroblocks, a single entry in a Huffman table is searched for. The single entry corresponds to the VLC and includes the joint differential x and y components of the motion vector. The Huffman table includes VLCs for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Specifically, claim 19 recites:

wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Applicants submit that the Examiner has not met the burden of establishing that claim 19 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 19.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences,” as recited in claim 19.

Accordingly, the rejection of claim 19 should be reversed.

**7. Claim 20**

Claim 20 is directed to a method for variable length coding block motion information of video images in a video coder. A joint parameter represents x and y motion vector components for a block. The method comprises assigning a single VLC selected from a set of available VLCs to the joint x and y motion vector components. Training determines which joint x and y motion vector components to represent in the set of available VLCs.

Specifically, claim 20 recites:

wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

Applicants submit that the Examiner has not met the burden of establishing that claim 20 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 20.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, “wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes,” as recited in claim 20.

Accordingly, the rejections of claims 20 and 21 should be reversed.

**8. Claim 22**

Claim 22 is directed to variable-length decoding macroblock motion information of a predicted video frame. A single VLC represents joint differential x and y components of a motion



vector for each of plural macroblocks. For each of the plural macroblocks, a single entry in a Huffman table corresponding to the VLC for the macroblock is searched for. The single entry includes the joint differential x and y components of the motion vector for the macroblock. The Huffman table includes VLCs for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Specifically, claim 22 recites:

wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.

Applicants submit that the Examiner has not met the burden of establishing that claim 22 is anticipated by Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 22.

Yu describes a VLC table that includes pairs of joint DMV components. However, the pairs of joint DMV components in the VLC table in Yu are determined *before use of a training set of video sequences*. This assumes that each and every pair of DMV x and y components in Region A is more likely to occur than any DMV pair in Regions B or C. While Yu describes using a training set of video sequences, the training set is not used to determine which pairs of DMV components will be represented in the VLC table. Thus, Yu does not teach or suggest, "the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences," as recited in claim 22.

Accordingly, the rejection of claim 22 should be reversed.

**C. The Rejections of Claims 5-6 and 10 Under 35 U.S.C. § 103 as Being Obvious in View of Yu Should Be Reversed.**

Claims 5-6 and 10 stand rejected under 35 U.S.C. § 103 as being obvious in view of Yu. Yu fails to teach or suggest at least one element of each one of these claims. Moreover, nothing in Yu

would lead one of ordinary skill in the art to modify the system described in Yu to achieve the claimed limitations. Accordingly, the rejections of claims 5-6 and 10 should be reversed.

**1. Claims 5-6**

Claims 5 and 6 depend from claim 1 and incorporate the language of claim 1.

Applicants submit that the Examiner has not met the burden of establishing that claims 5 and 6 are obvious in view of Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 1. Therefore, Yu does not teach or suggest at least one element of each of claims 5 and 6. Moreover, nothing in Yu would lead one of ordinary skill in the art to modify the system described in Yu to achieve each of the limitations of claims 5 and 6. Accordingly, the rejections of claims 5 and 6 should be reversed.

**2. Claim 10**

Claim 10 depends from claim 7 and incorporates the language of claim 7.

Applicants submit that the Examiner has not met the burden of establishing that claim 10 is obvious in view of Yu. Specifically, Yu does not teach or suggest the above-cited language of claim 7. Therefore, Yu does not teach or suggest at least one element of claim 10. Moreover, nothing in Yu would lead one of ordinary skill in the art to modify the system described in Yu to achieve each of the limitations of claim 10.

Accordingly, the rejection of claim 10 should be reversed.

**IX. CONCLUSION**

The final rejection failed to establish anticipation of claims 1, 3-4, 7-9, 11-13, and 15-22 by Yu. The final rejection also failed to establish the obviousness of claims 5-6 and 10 in view of Yu.

Accordingly, the rejections of these claims should be reversed and all claims should be passed to issue.

Respectfully submitted,

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**APPENDIX A: CLEAN COPY OF CLAIMS INVOLVED IN THE APPEAL**

1. (Amended) In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

predicting x and y motion vector components for a current block of pixels based on a motion vector of at least one neighboring block of pixels to compute x and y components of a predictor motion vector;

computing differential x and y components from the x and y components of the predictor and x and y components of a motion vector for the current block; and

assigning a single variable length code to joint x and y differential motion vector components, wherein the single variable length code is assigned from a variable length code table, the table comprising a list of pairs of joint differential motion vector components and a corresponding variable length code for each pair, such that shorter variable length codes are assigned to joint differential motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence, wherein the table includes the most probable pairs of joint differential motion vector components as computed by statistical analysis of example video sequences.

2. (Cancelled)

3. (Amended) The method of claim 1 wherein the assigning includes:

looking up the joint differential motion vector components in the table;

when no match is found in the table, coding an escape code along with a fixed length code for each differential motion vector component.

4. (Twice Amended) The method of claim 1 wherein the block of pixels corresponds to a macroblock in a video frame divided into fixed-sized, rectangular macroblocks, and the predicting, computing, and assigning are repeated for the macroblocks in the video frame.

5. (Twice Amended) The method of claim 1 wherein the block of pixels corresponds to a macroblock of a video object plane in video frame having two more video object planes, and the video object planes are each divided into fixed-sized, rectangular macroblocks; and

the predicting, computing and assigning are repeated for the macroblocks in the video object planes.

6. (Amended) A computer readable medium having instructions for performing the method of claim 1.

7. (Amended) In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

receiving a single variable length code representing joint x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in an entropy codebook corresponding to the variable length code and including the x and y components of the motion vector, wherein training determines which x and y components to include in the entropy codebook; and

using the x and y components of the motion vector from the codebook to define motion of pixels in a corresponding macroblock.

8. (Unchanged) The method of claim 7 wherein the x and y components of the motion vector in the codebook comprise x and y differential motion vector components, and the method comprises:  
reconstructing the motion vector from the differential motion vector components and x and y components of a predictor motion vector.

9. (Unchanged) The method of claim 7 wherein the codebook is a Huffman table trained for a target bit rate and content type from a statistical analysis of example video sequences having the content type.

10. (Amended) A computer readable medium having instructions for performing the method of claim 7.

11. (Amended) A motion vector encoder comprising:  
a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;  
a subtractor for computing differential motion vector components from motion vector components of the predictor and the motion vector of the block of pixels; and  
a joint entropy coder for jointly coding the differential motion vector components with a single variable length code, wherein statistical analysis indicates which differential motion vector components to represent with variable length codes and which differential motion vector components to represent with an escape code followed by fixed length codes.

12. (Unchanged) The encoder of claim 11 wherein the joint entropy coder computes the single variable length code by searching for the code in a Huffman coding table comprising a list of

joint differential motion vectors and a corresponding variable length code for each of the joint differential motion vectors.

13. (Amended) A motion vector decoder comprising:

a motion vector predictor for computing a motion vector predictor for a motion vector of a block of pixels from at least one motion vector for a neighboring block of pixels;

a joint entropy decoder for decoding a single variable length code into joint differential motion vector components, wherein the joint entropy decoder decodes the single variable length code by searching for the code in a Huffman coding table comprising a list of variable length codes and corresponding joint differential motion vector components for each of the variable length codes, wherein training determines which joint differential motion vector components to include in the table and which joint differential motion vector components to exclude from the table; and

an adder for reconstructing X and Y motion vector components from the joint differential motion vector components and X and Y components of the motion vector predictor.

14. (Cancelled)

15. (Unchanged) The decoder of claim 13 wherein the joint entropy decoder is operable to detect an escape code indicating that two fixed length codes representing X and Y differential motion vector components follow the escape code.

16. (Amended) In a video coder for coding video images in a block format, a method for improving compression of the video images comprising:

computing x and y motion vector components for a block;

forming the x and y motion vector components into a joint parameter representing joint x and y motion vector components; and

assigning a single variable length code to the joint x and y motion vector components, the single variable length code selected from a set of available variable length codes, such that shorter variable length codes are assigned to joint motion vector components that have a higher probability of occurrence in the video images, and longer variable length codes are assigned to joint differential motion vector components that have a lower probability of occurrence, wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

17. (Unchanged) The method of claim 16 further including spatially predicting the x and y motion vector components from a neighboring block of the block; and using spatially predicted components as the joint x and y motion vector components.

18. (Unchanged) The method of claim 17 wherein the spatially predicted components are differential motion vector components computed as a difference between x and y components of the motion vector for the block and x and y components of a predictor motion vector.

19. (Amended) In a video decoder, a method for decoding macroblocks of a predicted video frame comprising:

receiving a single variable length code representing joint differential x and y components of a motion vector for each of the macroblocks;

for each of the macroblocks, searching for a single entry in a Huffman table corresponding to the variable length code and including the joint differential x and y components of the motion vector,



wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences;

computing x and y components of a predictor motion vector from neighboring macroblocks to the macroblock currently being decoded; and

reconstructing the motion vector from the differential components obtained from the Huffman table and the x and y components of the predictor motion vector.

20. (Unchanged) In a video coder for coding video images in a block format, a method for variable length coding block motion information of the video images, wherein a joint parameter represents x and y motion vector components for a block, the method comprising:

assigning a single variable length code selected from a set of available variable length codes to the joint x and y motion vector components, wherein training determines which joint x and y motion vector components to represent in the set of available variable length codes.

21. (Unchanged) The method of claim 20 wherein the block is a 16x16 macroblock of pixels, and wherein each of the x and y motion vector components comprises a differential value.

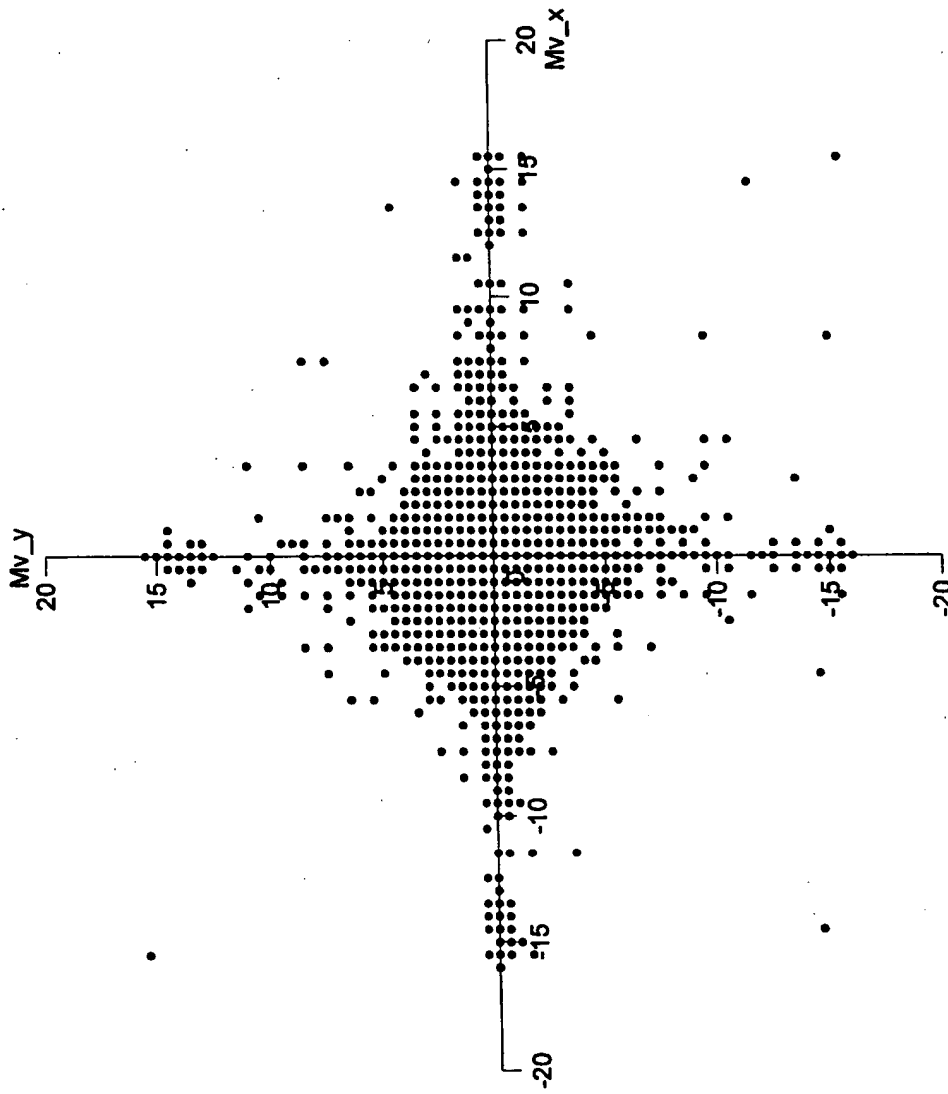
22. (Unchanged) A video decoder including computer-executable instructions for causing a computer programmed thereby to perform a method for variable length decoding macroblock motion information of a predicted video frame, wherein a single variable length code represents joint differential x and y components of a motion vector for each of plural macroblocks, the method comprising:

for each of the plural macroblocks, searching for a single entry in a Huffman table corresponding to the variable length code for the macroblock, wherein the single entry includes the

joint differential x and y components of the motion vector for the macroblock, wherein the joint differential x and y components are combinable with predictor x and y components to reconstruct the motion vector for the macroblock, and wherein the Huffman table includes variable length codes for the most probable joint differential x and y components as computed by statistical analysis of example video sequences.



**Appendix B: Plot of DMV Pairs Represented in VLC Table for Talking Head Video in One Embodiment**





Appendix C: Plot of DMV Pairs Represented in Yu VLC Table

